Available online at www.sciencedirect.com

SciVerse ScienceDirect

Physics Procedia 24 (2012) 362 – 367

Physics Procedia

2012 International Conference on Applied Physics and Industrial Engineering

Research on Simulation Inspection Detector

Lixia Sun and Kaibao Wang, Xiangyan Lv, Shengyuan Jiang and Jianbo Jia
College of Mechanical Engineering
Beihua University
Jilin, China

Abstract

The structure design problems of simulation inspection detector on ground are researched in this paper. The general design scheme is proposed based on the design task requirements of simulation inspection detector with a synthetic consideration on the requirements of the whole mass and the real grounded force. Detailed design for the concrete mechanical strcture has been carried out. The prototype of simulation inspection detector meets the test requirements, which can also provide important reference for the detector improvement.

Keywords:Simulation inspection detector; Hanging System; Differential balancing Mechanism; Concrete design

1. Introduction

Lunar inspection detector (called inspection detector for shorted) is an important tool which can do exploration, analysis and sampling on the lunar surface[1~2]. The mobile system is equipted with a lot of detection instrumentations, wireless communication equipments and control equipments, so better structural reliability, steady movement, obstacle negotiation and anti-side tumbing ability are required with the inspection detector[3~4].

During emission process, explosive bolts are required to compact the inspection detector bodywork onto the release mechanism. When the lander landed, the inspection detector bodywork is unlocked by explosive bolts exploding. The inspection detector bodywork can arrive on the surface of the moon together with transfer mechanism with the lift effect of pressure -release mechanism. The bodywork posture changes in the explosion-unlocking process, and the transfer ability of inspection mechanism and transfer mechanism is affected.

Based on the above reasons consideration, simulation inspection detector prototype design is proposed in this paper. The posture change and pressure -release mechanism function of real detector can be simulated in the explosion-unlocking process.

doi:10.1016/j.phpro.2012.02.053

2. The design requirements for simulaiton inspection detector

The ground simulation inspection detector with double rocker was used in verifying the relationship between inspection detector and lander, simulating posture change and pressure -release mechanism function in the explosion-unlocking process. The needed concrete design tasks can be shown as follows:

1) Smulation in one-sixth gravitational field;

2) Mechanical interface dimension between the simulation inspection detector and the lander is consistent with real conditions, and interface stiffness is close to real conditions;

3) Real grounded force for each wheel of simulation inspection detector is consistent with the real conditions, and the simulation inspection detector bodywork is stable;

4) The centroid position of simulation inspection detector is consistent with the real value of furl state inspection detector in transverse direction;

5) The environmental temperature of simulation inspection detector is between - 80 ℃ and + 100 ℃.

3. General design scheme for simulation inspection detector

Aiming at the above design requirements, profound researches are processed on the simulation inspection detector based on the design idea of reducing total quality and reflecting the wheel real grounded force.

A sixth of real inspection detector(130kg) is adopted as the design quality of simulation inspection detector, which can simulate the one-sixth gravitational field. And the initial quality of simulation inspection detector is 21.7±0.5kg. The quality of simulation inspection detector grows to 32.55kg by increasing counterweight with considering detection instrumentations, camera equipments and communications equipments on the real inspection detector.

Mechanical interface form between the simulation inspection detector and the lander is consistent with real conditions. Pressing point position is adjusted by long hole mediation way, what can ensure perfect anastomosis between pressing point and test-bed interface. Frame structure form and strengthened structure are adopted in mechanical interface and bodywork connection design, which can make interface stiffness close to real conditions. The rocker of simulation inspection detector is according to real rocker.

The simulation inspection detector bodywork is stable with effects of the rocker differential balance mechanisms. The centroid position is adjusted by centroid adjusting mechanism of simulation inspection detector. In order to prevent the structural damage caused by welding residual stress in low temperature environment, welded structure application on simulation inspection detector should be reduced .

4. Mechanical structure design for simulation inspection detector

The simulation inspection detector is mainly composed of simulation wheel system, hanging system, differential balancing mechanism, pressing point interface mechanism and centroid adjusting mechanism. In order to ensure the simulation test requirements, detaied mechanical sructure design is carried out.

4.1 Structure design for simulation wheel system

The main function of simulation wheel system is to support simulation inspection detector bodywork and ensure the full contact between simulation inspection detector and pressure -release mechanism. The simulation wheel system is mainly composed of flange, spoke and pawl, which can be seen in Fig.1.

The geometrical models and structural dimension parameters for flange of simulation inspection wheel are consistent with real conditions, which can reflect the real grounded force.

The simulation flange and hanging system are connected by spoke of simulation inspection detector. In order to meet the testing requirements, frame class structure is adopted for simplified design of the simulation spoke. Mechanical connection is adopted between simulation spoke and flange, which can prevent the structural damage caused by welding residual stress in low temperature environment. So the design request of simulation inspection detector in low temperature environment can be satisfied.

Two pieces of pawl are staggered installated on the flange of simulation inspection detector, which can reflect the real grounded force for simulation wheel and pressure -release mechanism.

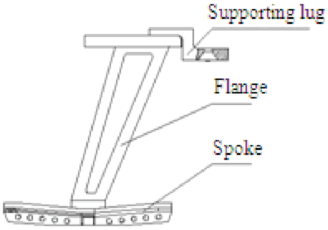

Figure 1. The structural diagram of simulation wheel system

4.2 Structure design for hanging system

The main effects of hanging system are to make simulation wheel system, differential balancing mechanism and peressing point interface mechanism connected together. The structure of hanging system is a symmetrical form, which is composed of main rocker, accessory rocker, rocker fittings, connecting rods, etc. The structural diagram of hanging system can be seen in Fig.2.

The key design of wheel track, wheel base, axle center position and hinged joint position is consistent with the structural dimension parameters of real inspection detector.

The main rocker of hanging system is connected with accessory rocker by two connectors. The main rocker and accessory rocker respectively connect to spoke of simulation wheel in mechanical mode by connecting rods.

On the premise of satisfaction with strength, stiffness and test performance requirements, replacing curve by straight line and weight reduction groove are adopted in reducing the whole quality of simulation inspection detector.

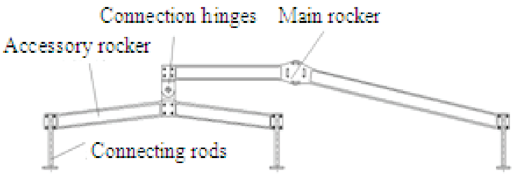

Figure 2. The structural diagram of hanging system

4.3 Structure design for differential balancing mechanism

The main effects of differential balancing mechanism are to effectively reduce the external disturbance on main bodywork and keep bodywork stable. The basic principle for differential balancing mechanism can be seen in Fig.3.

The formula be shown as follows: $\phi = \dfrac{\phi_1 + \phi_2}{2}$

Where ϕ—angle of differential shell;

ϕ_1—angle of left wheel;

ϕ_2—angle of right wheel;

Differential balancing mechanism is mainly composed of differential wheel system, differential half axle system and differential balancing mechanism, which can be seen in Fig.4.

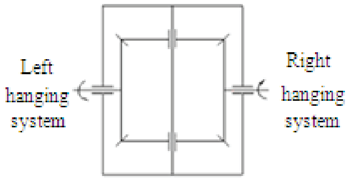

Figure 3. The schematic diagram of differential balancing mechanism

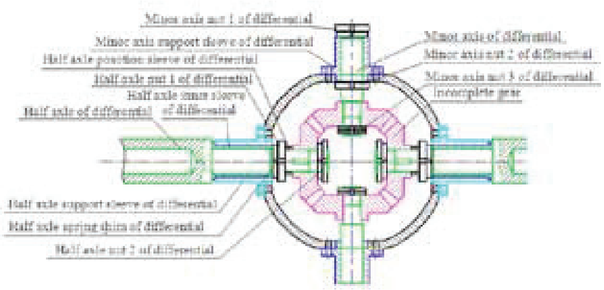

Figure 4. The structural diagram of differential balancing mechanism

The symmetric cone planetary gear differential mode of automotive drive axle is adopted in the design for differential wheel system of differential balancing mechanism. The angle between two hanging systems in the the release-unlocking process experiments of simulation inspection detector is relatively small, so incomplete gears are adopted in the cone gears design aiming at total quality reduction. The main design parameters of incomplete gears can be seen as follows: m=1.5mm, Z=48, α=20°.

Half axle of differential balancing mechanism is the core of differential balancing mechanism. The transfer function of movement and force for hanging system and connection of two hanging system is achieved by half axle. Half axle of differential balancing mechanism is mainly composed of half axle clamping support, half axle, half axle nuts, half axle inner sleeve, half axle position sleeve, etc. The half axle rotational part of differential balancing mechanism is composed of half axle, half axle clamping support and half axle inner sleeve. Transition fit is adopted between half axle and inner sleeve, and adjustable clearance fit is adopted between inner sleeve and clamping support.

The half axle of differential balancing mechanism is an important transmission part for differential balancing mechanism of simulation inspection detector. In order to reduce quality and ensure inherit torsional loading conditions, hollow shaft mode is adopted in the design of half axle. Axial dimensions of half axle should meet installation and positioning requirements for shaft parts. High-strength aluminum alloy material is adopted for half axle.

Differential balancing mechanism shell is the most important structural part in differential balancing mechanism, which can support the whole bodywork and transfer corresponding torque and moment. The shell structure can provide essential cavity for the flexible movement of differential gear system and support the central cone gear. The two shell sides can respectively provide a set of lateral support for half axle of differential.

4.4 Structure design for pressing point interface mechanism

The main effects of pressing point interface mechanism are to adjust simulation inspection detector bodywork, which can ensure the accurate docking between inspection detector, lander experimental platform and pressing point interface mechanism. The pressing point interfac position is composed of four pressing interfaces of bodywork and six pressing interfaces of simulation wheels, which is consistent with the real inspection detector. The guarantee for pressing point interfac position com is needed. Considering the processing and assembly error problems, X, Y and Z three coordinate direction adjustable form is adopted for the four pressing interfaces of bodywork and six pressing interfaces of simulation wheels.

Long hole adjusting way is adopted in X and Y two coordinate direction adjusting of the four pressing interfaces of bodywork, and Z coordinate direction adjusting can be achieved by increasing adjusting gaskets. The accurate docking between bodywork ang lander experimental platform can be ensured by X, Y, Z directioal adjusting. Four connecting rods are adopted for the connection between the carriage of simulation inspection detecor, which can be seen in Fig.5.

The same adjusting methods are adopted in six pressing point interfaces of simulation inspection detector wheels, which can ensure the full contact between wheels and pressure -release mechanism, which can be seen in Fig.6.

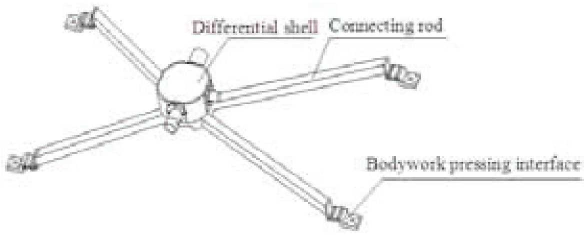

Figure 5. The structural diagram of pressing point interface mechanism

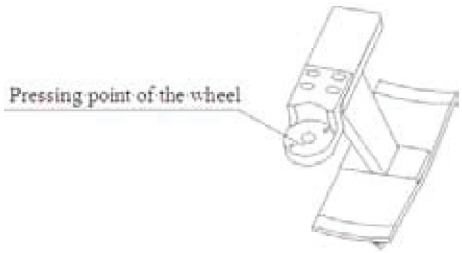

Figure 6. The structural connection diagram of pressing point interfaces of simulation inspection detector

4.5 Structure design for centroid adjusting mechanism

The main function of centroid adjusting mechanism is to adjust the bodywork quality of simulation inspection detector and make the centroid position of simulations inspection detector approaching to the real status by increasing counterweight blocks. The centroid adjusting mechanism is mainly composed of the slide(main rocker), adjusting slider, adjusting weights, adjusting scale and locking bolts, which can be seen in Fig.7.

The transverse coordinate for centroid position of simulation inspection detector is consistent with the real inspection detector. Before position adjusting, concrete adjusting value should be calculated by centroid coordinate formulas in space force system.

In centroid adjusting process, the centroid position adjustment can be obtained by adjusting the transverse slider position in certain conditions. The upper surface of main rocker is a plane, and the structure is regular. In order to simplify the structure of centroid adjusting mechanism, the main rocker is designed as centroid adjusting slide. The transverse centroid position can be adjusted by adjusting slider, and the requirements can be satisfied by adjusting weights.

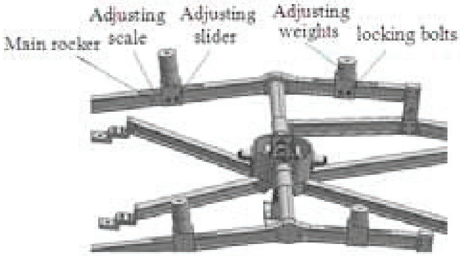

Figure 7. The structural diagram of centroid adjusting mechanism

5. Conclusion

Based on the design idea of reducing the whole quality and reflecting the real grounded force, the detailed design for mechanical structure of simulation inspection detector is carried out. The prominent advantages can be described as follows:

1) With the advantages of compact structure, easy handling and transportation, simplified design is adopted for simulation wheel system, hanging system, and pressing point interface mechanism.

2) The external disturbance to the simulation inspection detector bodywork is effectively reduced by the design of differential balancing mechanism, and the gear clearances is easy to adjust.

3) The centroid adjusting mechanism is simple and efficient. The satisfied centroid position can be adjusted by adjusting counterweights.

References

[1]Schenker P S, Huntsberger T L , Pirjanian P, etc, “Planetary rover developments supporting mars exploration”, Autonomous Robots , vol.14, pp.103–126, 2003.

[2]Ellery A, “Environment robot interaction the basis for mobility in planetary micro rovers”, Robotics and Autonomous Systems, vol.51, pp.1–11, 2005.

[3]Huang M H,David E, “Dynamic simulationof actively coordinated wheeled vehicle system on uneven terrain”, Proceedings of the 1999 IEEE International Conference on Robotics & Automation[C]. Detroit:IEEE Robotics and Automation Society, pp.202-211, 1999.

[3]Hirose S, Kuwahara H, WakabayashiY, etc, “Themobility design concepts/characteristics and ground testing of an offset-wheel rover vehicle”, Space Technology, vol.17, pp.183-193, 1997.